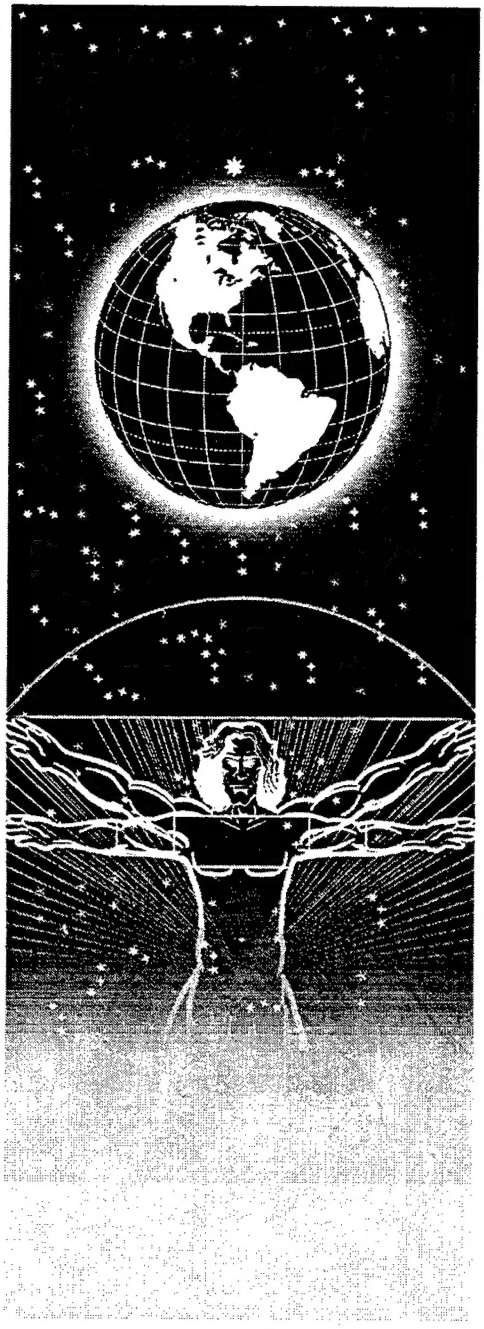
AL/OE-TR-1997-0118



UNITED STATES AIR FORCE
ARMSTRONG LABORATORY

Compliance Sampling of the Type "1" Classified Waste Incinerator Hickam AFB, Hawaii

Kyle W. Blasch, Captain, USAF, BSC

September 1997

Occupational and Environmental Health Directorate
Bioenvironmental Engineering Division
2402 E Drive
Brooks AFB, TX 78235-5114

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KYLE W. BLASCH, Capt, USAF, BSC
Consultant, Air Quality Function

LARRY T. KIMM, Major, USAF, BSC
Deputy Chief, Bioenvironmental
Engineering Division

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Armstrong Laboratory
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2402 E Drive
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Compliance emissions testing for total particulate matter was conducted on a Type "1" incinerator located at Building 83366, Hickam Air Force Base, Hawaii. The incinerator is currently used to destroy classified waste consisting of paper documents and cardboard containers. Sampling was performed from 1 August 1996 through15 August 1996 using Environmental Protection Agency Methods 1-5 contained in 40 CFR 60 Appendix A. Results indicate that the Type "1" incinerator is in full compliance with all applicable particulate matter emission standards.

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COMPLIANCE SAMPLING OF THE TYPE "1" CLASSIFIED WASTE INCINERATOR HICKAM AFB, HAWAII

INTRODUCTION

On 1-15 Aug 96, compliance emissions testing was conducted on a type "1" (Bldg. 83366)classified waste incinerator at Hickam AFB, Hawaii (Figure 1). A type "1" incinerator is defined as a solid waste incinerator which burns type "1" waste: a mixture of combustible waste such as paper, cardboard cartons, wood scrap, and foliage. The Hickam AFB incinerator burns primarily classified paper and cardboard waste.

The current particulate matter emissions requirement by the State of Hawaii for type "1" incinerators is 4.0 lb PM per ton of waste burned. This emission limit is less than the emission factor contained in AP-42 of 4.7 lb PM/ton for multiple chamber incinerators. The Environmental Flight (15 CES/CEV) at Hickam AFB requested the assistance of Armstrong Laboratory's Air Quality Function (AL/OEBQ) in quantifying the pollutant emissions from the incinerator to determine compliance status (see Appendices A&B). The emissions sampling results were used to determine whether the incinerator meets the 4.0lb/ton limit. Pollutants monitored during the survey included total particulate matter (PM), oxygen (O_2), and carbon monoxide (CO). Environmental Protection Agency (EPA) Method 5 contained in 40 CFR 60 Appendix A was used to sample for total particulate matter.

Site and Incinerator Description

The Hickam AFB type "1" incinerator is an Advanced Combustion Model No. CA 750, Serial No. 5933. This incinerator consists of both a primary (lower) and secondary (upper) chamber. Loading of the waste is accomplished by one entry port on the front of the incinerator (Figure 2 and 3). The incinerator uses multiple diesel-fired burners for each chamber. The incinerator is currently utilized to burn type "0" waste and has a design (rated) capacity of 750 lb/hr.

Figure 1. Type "1" Incinerator (left) and Silver Reclamation Incinerator (right) at Hickam AFB, Hawaii.

The type "1" incinerator is scheduled to burn two charges per week. Each charge weighs 250 lb on average. The batch is allowed to burn until all refuse is reduced to ashes. Most of the batch is burned within the first hour and the remaining portion of the waste smolders until it no longer burns. Typically the smoldering lasts approximately 24 hours.

The type "1" incinerator is equipped with a screen at the top of the stack to control large particulates (see Figure 1 and 3). It is not equipped with further control devices.

Applicable Standards and Guidelines

According to the State of Hawaii regulations, Title II Chapter 60.12, the TPM emission standard is 4.0 lb/ton (2 g/kg) from a type "1" incinerator. In order to determine compliance with this standard the incinerator needed to be sampled or an appropriate emission factor determined. The EPA's emission factor document, AP-42, was consulted for emission factors. Unfortunately, the EPA AP-42[1] TPM emission factor for the type "1" incinerator is 4.7

lb/ton. This exceeds the allowable limit for the State of Hawaii 4.0 lb/ton limit. As a result emissions testing was conducted to determine the total particulate matter emission rate.

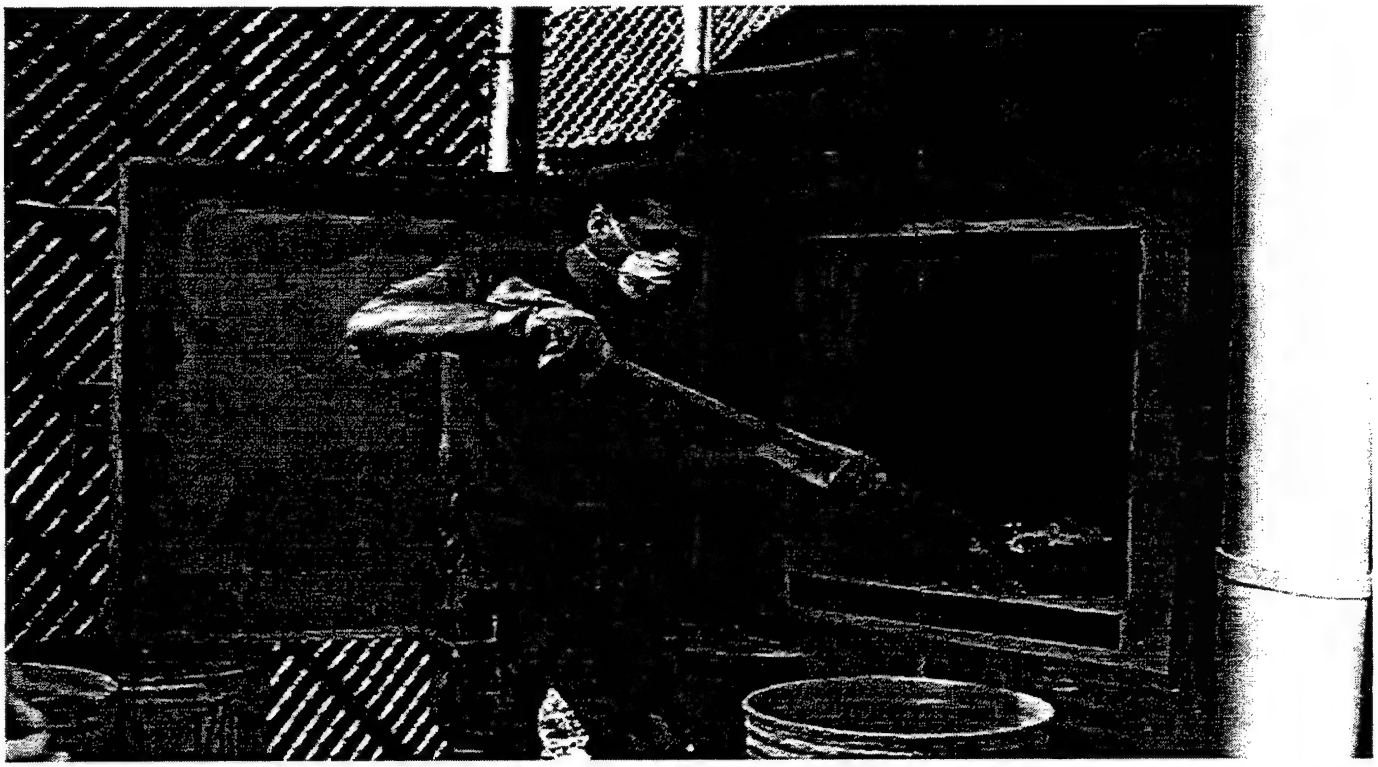


Figure 2. Front end loading of Type "1" incinerator.

METHODS AND MATERIALS

Particulate sampling and analysis were conducted in accordance with Environmental Protection Agency (EPA) Methods 1 through 5. These methods are found in Appendix A to Title 40, Code of Federal Regulations, Part 60[3]. As indicated previously, each burn can last up to 24 - 36 hours in length, however most of the waste is consumed in the first hour. Sample runs were started at the beginning of each burn and assumed to collect most of the particulate matter mass released.

The incinerator exhaust stack is circular with an inside diameter of 36 inches (see Figure 4). The Type "1" incinerator stack is 226 inches tall. Each stack has 2 sampling port holes. The sampling ports are on the same horizontal plane, 90 degrees apart. The sampling ports for the Type "1" incinerator are located 54 inches upstream from the stack exit and 172 inches downstream from the last stack disturbance (Figure 4). EPA Method 1 requires the sampling port holes to be located a minimum of 0.5

duct diameters upstream and 2.0 duct diameters downstream of the nearest flow disturbances. The ports are 1.5 duct diameters upstream (the stack exit)and 4.8 duct diameters downstream (incinerator exit).

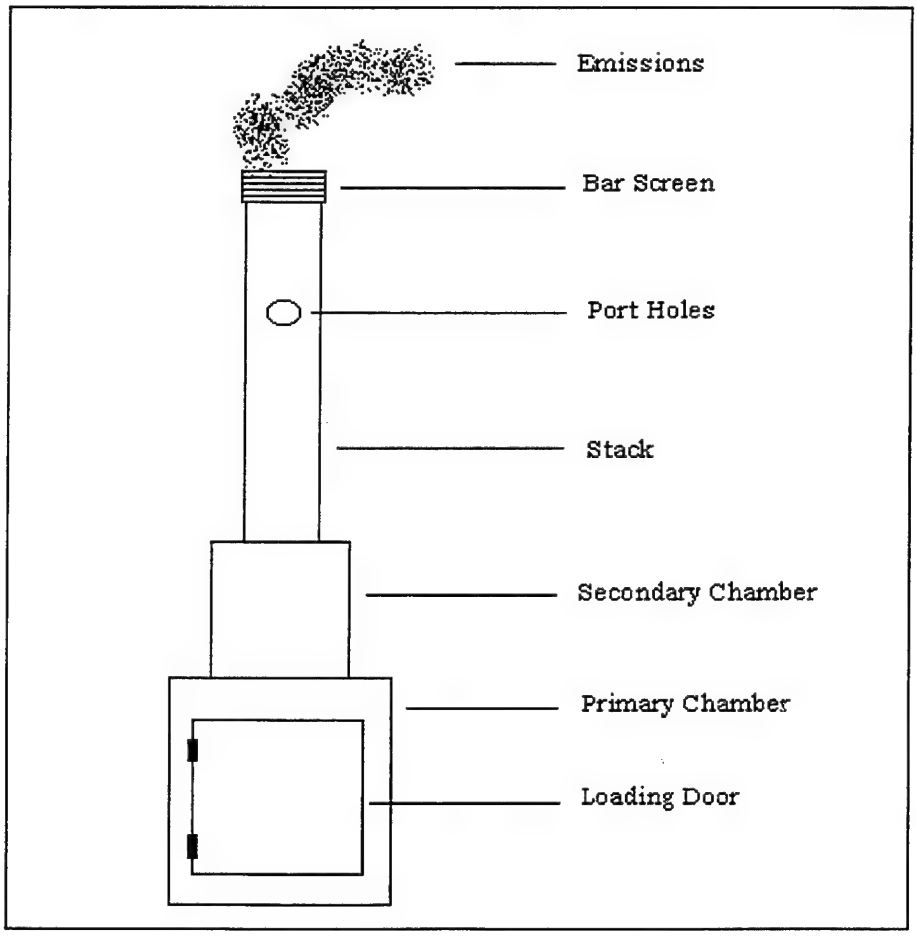
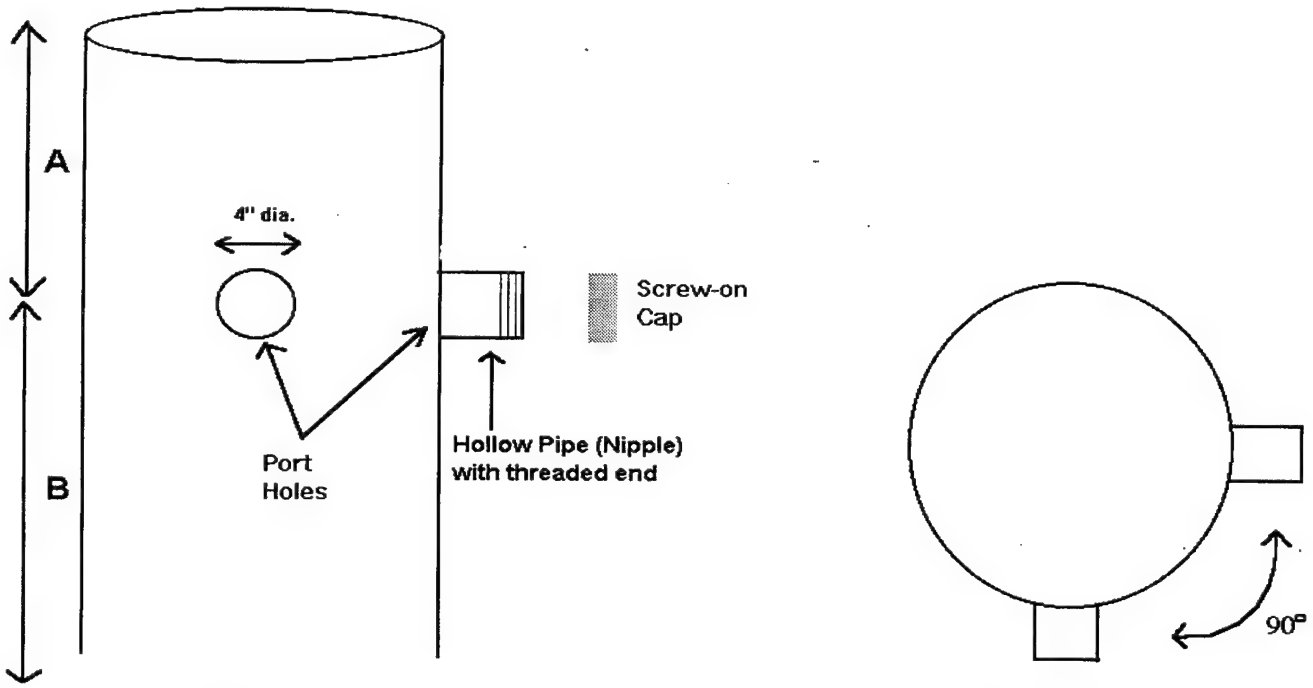


Figure 3. Schematic of Type "1" incinerator. (Not to Scale)



Notes

1. **A** = Distance from center of port holes to the nearest flow disturbance downstream. If possible, this distance should be ≥ 2 stack diameters. At a minimum, this distance must be ≥ 0.5 stack diameters. (For the Type "1" Incinerator A = 54".)
2. **B** = Distance from center of port holes to the nearest flow disturbance upstream. If possible, this distance should be ≥ 8 stack diameters. At a minimum, this distance must be ≥ 2 stack diameters. (For the Type "1" Incinerator B = 172".)

Figure 4. Locations of Exhaust Stack Sampling Ports

The EPA's Hewlett-Packard 41 (HP 41) "METH 1" calculator program was used to determine locations and numbers of traverse points[4]. A total of 24 traverse points (12 for each port hole) were used to collect a representative sample from the Type "1" incinerator.

Prior to the first sampling run, the average degree of cyclonic flow was determined by using a Type-S pitot tube and measuring the stack gas rotational angle at each point along the center traverse. Flow conditions are considered acceptable when the arithmetic mean average of the rotational angles is 20 degrees or less. Rotational angle measurements showed the Type "1" incinerator's air flow to be within acceptable limits. A preliminary velocity pressure traverse, using the same Type-S pitot tube, was also accomplished at this time.

A grab sample for Orsat analysis (measures O_2 and CO_2 for stack gas molecular weight determination) was taken during each sampling run (see Figures 5 & 6)

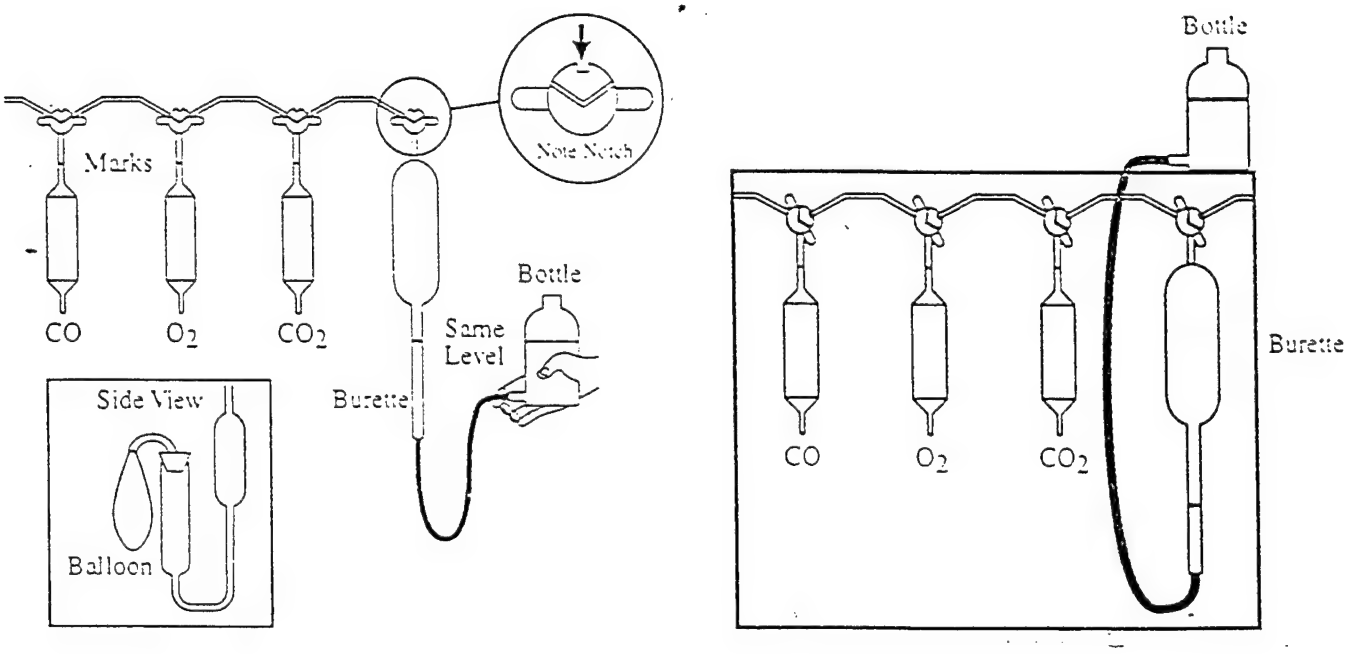


Figure 5. Schematic of Orsat Analyzer

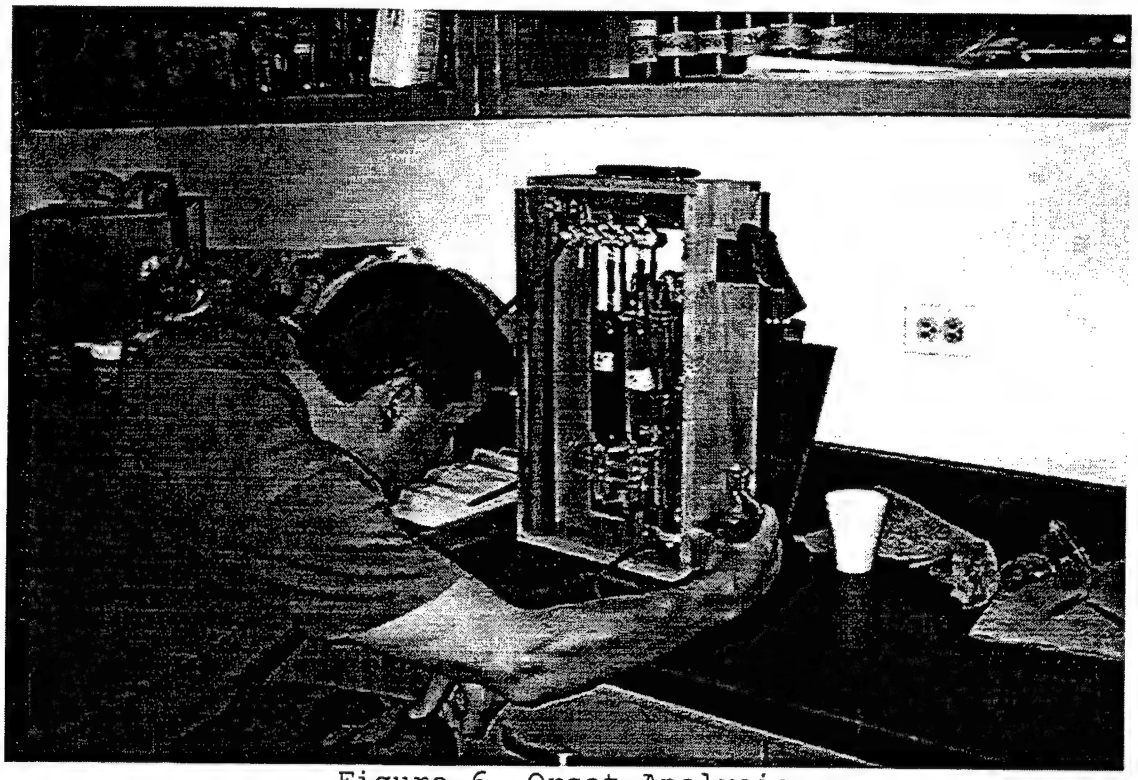


Figure 6. Orsat Analysis

For each representative sample, 3 sampling runs were conducted and the results averaged to determine the final emission value. All sampling runs were 60 minutes in duration.

The particulate matter content, moisture, velocity, and temperature of the exhaust stack gas were determined using an EPA Method 5 sampling train. The train consisted of a button-hook probe nozzle, heated stainless steel probe, heated glass-fiber filter, impingers, and a pumping/metering device (meter box). A schematic of the Method 5 sampling train is shown in Figure 7 and a picture of a Method 5 sampling train in the field is shown in Figure 8. Calibration data for the Method 5 equipment are found in Appendix C. Calibrations were performed in accordance with EPA's Quality Assurance Handbook.[5] Stack gas velocity pressure was measured at the nozzle tip using a Type S pitot tube connected to a 10-inch inclined-vertical manometer and the procedures described in EPA Method 2. The probe nozzle was sized (with a micrometer) prior to sampling using EPA Method 5 criteria. Type K thermocouples were used to measure stack gas and sampling train temperatures. The probe liner was heated to minimize moisture condensation. The heated filter was used to filter out particulates prior to the impingers. The impinger train consisted of four glass impingers in series. The impinger train was placed in an ice bath which enabled the stack gas moisture to condense into the impingers. The first, third, and fourth impingers were of modified Greenburg-Smith design while the second impinger was a

standard Greenburg-Smith type. The first and second impingers each contained 100 milliliters (ml) of distilled water, the third impinger was empty, and the fourth impinger contained 200 grams (g) of silica gel.

The pumping and metering system was used to control and monitor the sample gas flow rate. The velocity and flow rate of the stack gas were calculated using the EPA's HP 41 "METH 2" Calculator Program. The percent moisture of the exhaust stack gas was calculated using the EPA's Hewlett-Packard 41 (HP 41) "METH 4" Calculator Program. Printouts from all the HP 41 programs run for this survey are found in Appendix D.

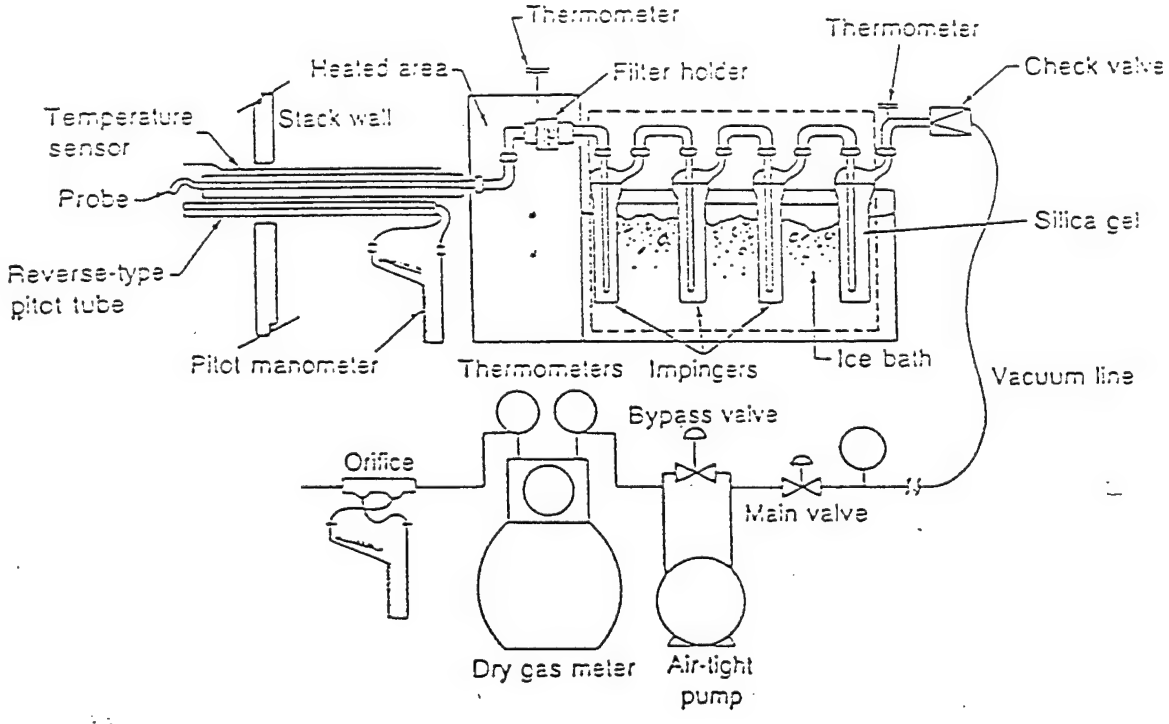


Figure 7.0 Schematic of EPA Method 5

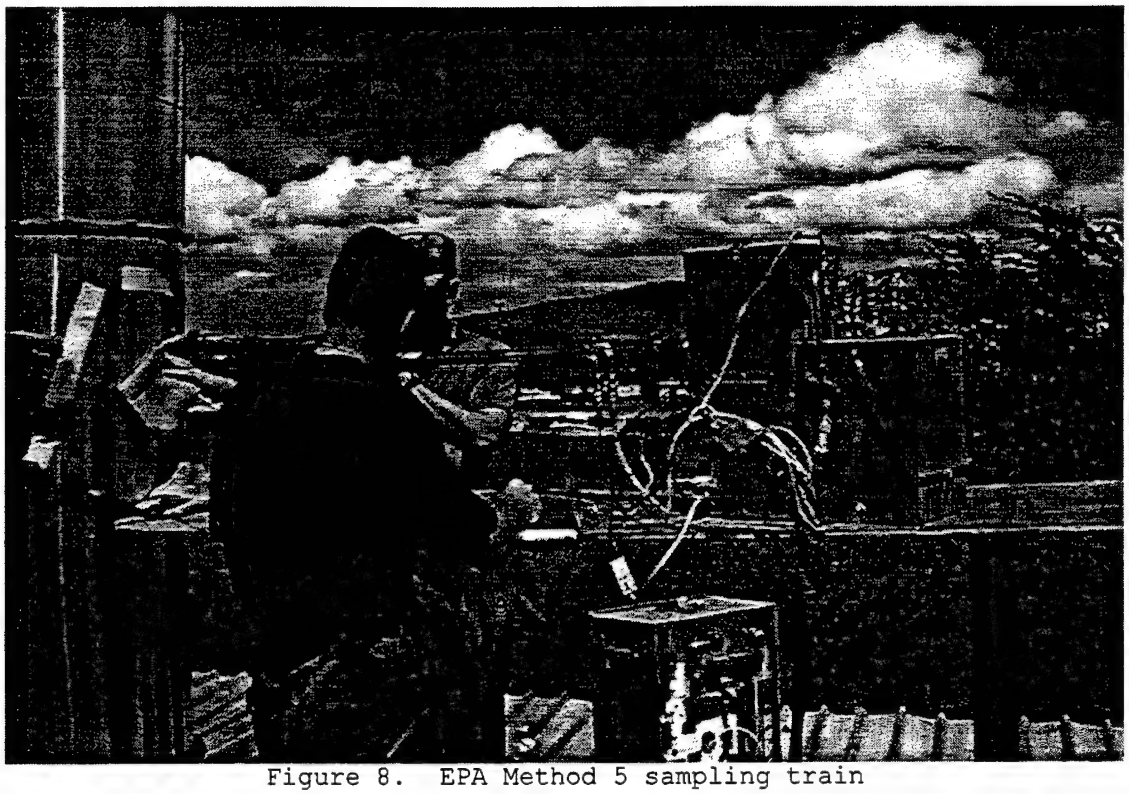


Figure 8. EPA Method 5 sampling train

Front half particulate matter mass (material collected on sampling train surfaces up to and including the filter) was determined for compliance purposes according to the procedures specified in EPA Method 5. Field data from particulate sampling are presented in Appendix E. Emission calculations were accomplished using the "Source Test Calculation and Check Programs for Hewlett-Packard 41 Calculators" developed by the EPA Office of Air Quality Planning and Standards.

Quality Assurance/ Quality Control

Copies of all supporting calibration and quality assurance date are in the appendices.

Pre-survey

Prior to the survey, several steps were taken to calibrate equipment and prepare the sample filters. The meter box contains a dry gas meter that was calibrated using another dry gas meter. Although a dry gas meter is considered a secondary standard it can be used in lieu of a primary standard provided it is calibrated by a transfer standard whose calibration is traceable to a primary standard (i.e., wet test method). The purpose of this calibration is to ensure the volume collected as indicated by the meterbox is a measure of the true volume collected. Sample filters were pre-

dried in a dessicator for twenty-four hours and weighed to the nearest 0.1 milligram. They were placed back in the dessicator and re-weighed 6 hours later. If the weights were within 0.5 milligrams the average weight was recorded on a resealable plastic bag and the filter placed in it. Pitot tubes used to measure velocity were also calibrated within standards, correction factors determined, and recorded.

Survey

During the survey several steps were taken to ensure sample accuracy and precision. When the sampling train is assembled a leak test of the sample train and pitot tube was conducted before and after each sample run. Additionally, the nozzle selected for a particular run was measured using a micrometer and the diameter recorded on a calibration sheet.

Post-Survey

Upon completion of the sample run, the filter was removed and placed in aluminum foil which in-turn was labeled and placed in the resealable plastic bag. Post weighing was performed at Armstrong Laboratory using the same procedures indicated in EPA Method 5. The stainless steel probe was rinsed and brushed into a sample container at the on-site laboratory with acetone. This collects any particulate matter that may have adhered to the inside of the probe. The sample jars were labeled with run number, level of rinse (used to determine if a jar leaked during transport), and finally shipped to Armstrong Laboratory. At Armstrong Laboratory the acetone rinse was transferred to preweighed beakers. The volume of acetone was recorded and the beakers were placed in a controlled ventilation hood. After the acetone had evaporated the beakers were weighed in the same manner as the filters. The acetone residual weight was calculated and normalized to a QA/QC probe rinse. The impinger contents were measured using a graduated cylinder and electronic balance.

RESULTS

Sample results for particulate matter are shown in Table 1. Total particulate matter is a combination of PM collected on the filter and PM collected from rinsing the EPA Method 5 train components.

Table 1. Total Mass of Particulate Matter Collected

Test Run #	Filter PM Collected (lb)	Rinse PM Collected (lb)	Total Particulate Matter (lb)
TYPE"1" - 1	2.62E-04	1.84E-04	4.46E-04
TYPE"1" - 2	N/A	N/A	N/A
TYPE"1" - 3	4.80E-05	1.72E-04	2.28E-04
TYPE"1" - 4	8.16E-05	1.80E-04	2.62E-04

Table 2 shows the calculated particulate matter emissions rates. The amount of particulate matter captured in the EPA Method 5 train is adjusted to reflect the total particulate emissions from the stack. The sampling train's dry gas meter records the amount of exhaust gas collected through the train. At the same time, pitot tube readings from within the stack determine the stack gas velocity. By knowing the stack gas velocity, stack area and time sampled it is possible to determine the total gas exhausted through the stack. Total particulate matter is then determined by multiplying the particulate matter collected through the train by the ratio of gas collected through the train to the total gas exhausted through the stack. The total particulate matter value is then divided by the amount of waste incinerated to determine the emission rate.

Table 2. Total Mass of Particulate Matter Emitted

Test Run #	Total PM Emitted (lb)	Amount of Waste Incinerated (ton)	Total PM Emitted Per Waste Incinerated (lb/ton)
TYPE"1" - 1	4.46E-04	0.284	3.65
TYPE"1" - 2	N/A		N/A
TYPE"1" - 3	2.28E-04	0.147	3.61
TYPE"1" - 4	2.62E-04	0.132	4.61

Table 3 shows the average emissions and compliance standard.

Table 3. Incinerator Compliance Results

Test Run #	Total PM Emitted (lb/ton)	Total PM Standard (lb/ton)	Compliance Status
TYPE"1" - 1	3.80		
TYPE"1" - 2	N/A		
TYPE"1" - 3	3.48		
TYPE"1" - 4	4.39		
Average	**3.89**	4.0	Yes

DISCUSSION

Results from the particulate matter emissions testing for the Type "1" Incinerator are below State of Hawaii Permit limits. Operators of the incinerator should ensure that the temperature and retention time in the secondary chamber is sufficient to maintain complete combustion.

Results for the second run are not shown because the wrong input data was used in the HP41 calculator program. The values obtained were not considered valid. A fourth run was administered to obtain three complete and valid data sets.

Visual inspections of the stack exhausts showed a decrease in particulate matter released after the first forty minutes. This is consistent with the test methodology previously stated. Inspections of the incinerated material after a 2-4 hours showed very little remaining combustion and after 12 hours there were no visible cinders.

REFERENCES

1. Compilation of Air Pollution Emission Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, AP-42, Office of Air Quality Planning and Standards (OAQPS), U.S. Environmental Protection Agency (EPA), Research Triangle Park (RTP), North Carolina (NC), January 1995.

2. Hawaii Regulations, Title 11, Chapter 60.1, "Air Pollution Control"

3. Office of the Federal Register National Archives and Records Service, Code of Federal Regulations, Title 40, Part 60, Washington DC, July 1994.

4. U.S. Environmental Protection Agency, Source Test Calculation and Check Programs for Hewlett-Packard 41 Calculators, EPA-340/1-85-018, Research Triangle Park NC, May 1987

5. U.S. Environmental Protection Agency, Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III. Stationary Sources Specific Methods, EPA/600/4-77/-07b, Research Triangle Park NC, December 1984

APPENDIX A

Personnel Information

Armstrong Laboratory Air Quality Test Team

Capt Kyle W. Blasch, Air Quality Consultant, Project Officer
Capt Thomas C. Moore, Air Quality Consultant
Capt Greg P. Durand, Air Quality Consultant

AL/OEBQ
2402 E Drive
Brooks AFB TX 78235-5114
Phone: DSN 240-3305
Comm (210) 536-3305

Hickam AFB On-Site Representatives

Mr. Melvin Muraoka
15 CES/CEV
75 H Street
Hickam AFB, HI 96853-5233
Phone: DSN 449 - 8998
Comm (808) 449-8998

APPENDIX B

DEPARTMENT OF THE AIR FORCE
PACIFIC AIR FORCES

20 MAY 1996

MEMORANDUM FOR AL/OEBQ
2402 E. DRIVE, BUILDING 175W
BROOKS AFB TX 78235-5114

FROM: 15 CES/CEV
75 H Street
Hickam AFB HI 96853-5233

SUBJECT: Air Sampling Work - Title V

1. Armstrong Laboratory (AL) is scheduled to conduct National Emission Standard for Hazardous Air Pollutants (NESHAP) work on Hickam AFB during the Jul/Aug timeframe. During this period, we would like AL to conduct source sampling on two incinerators located on Hickam AFB.

2. During our annual air emission update/Title V permit review, we identified a possible compliance issue with our incinerators. EPA AP-42 air emission factors indicate the following emissions for PM-10 (Particulate Matter - less than 10 micron diameter).

Type Incinerator	Emission Rate
Type "O" waste incinerator	5.7 lb/ton
Silver reclamination incinerator	4.7 lb/ton

3. The State of Hawaii limitation for all incinerators is 4.0 lb/ton. Source testing for PM-10 needs to be conducted on these two incinerators to determine compliance status.

4. Please contact Mr. Melvin Muraoka at (808) 449-8998 to discuss any items.

MICHAEL F. MCGHEE, P.E.
Chief, Environmental Flight
15th Civil Engineer Squadron

APPENDIX C

METER BOX CALIBRATION DATA AND CALCULATION FORM			
English Units			
Meter Box Number:	4	Date:	12-Jul-96
Barometric Pressure, Pb, in.Hg:	29.41		

Preliminary Test Calibration									
Orifice Manometer Setting (ΔH) in. H_2O	Gas Volume		Temperatures				Time	Y_i	$\Delta H@_i$
	Wet Test Meter (V_w) ft^3	Dry Gas Meter (V_d) ft^3	Wet Test Meter (t_w) °F	Dry Gas Meter			(Θ) min		in. H_2O
				Inlet (t_{di}) °F	Outlet (t_{do}) °F	Avg (t_d) °F			
0.50	5	4.985	74	77	76	76.5	12.35	1.006447	1.747596
1.00	5	4.99	76	82	78	80	8.5	1.006964	1.657288
1.50	10	10.43	76	86	80	83	14.31	0.967665	1.751719
2.00	10	10.145	75	90	83	86.5	12.74	1.001886	1.832527
3.00	10	10.035	76	93	84	88.5	10.32	1.01216	1.803839
4.00	10	9.99	75	96	86	91	8.93	1.02073	1.786007
							Average	1.002642	1.763163

$$Y_i = \frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6} \right) (t_w + 460)}$$

$$\Delta H@_i = \frac{0.0317}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\Theta}{V_w} \right]^2$$

Date:		Post Test Calibration							
Orifice Manometer Setting (ΔH) in. H_2O	Gas Volume		Temperatures				Time	Y_i	$\Delta H@_i$
	Wet Test Meter (V_w) ft^3	Dry Gas Meter (V_d) ft^3	Wet Test Meter (t_w) °F	Dry Gas Meter			(Θ) min		in. H_2O
				Inlet (t_{di}) °F	Outlet (t_{do}) °F	Avg (t_d) °F			
2.50	10	10.265	68	74	73	73.5	12.17	0.978218	2.085541
2.50	10	10.29	70	80	74	77	12.31	0.978536	2.135983
2.50	10	10.17	72	85	77	81	12.24	0.993708	2.111996
							Average	0.983487	2.111173

Run	Pre test Calibration Factor	Post Test Calibration Factor	Change	% Change
#1	1.002642	0.98349	0.019155	1.910453

Operator: Kyle Blasch Signature: KyleBlasch

Quality Assurance Handbook M5-2.3A

Nozzle Calibration Data Form

Location: BROOKS AFB Date: 25 Aug 95

Nozzle Identification Number	Nozzle Diameter[a]						ΔD[b]		D_{avg}[c]	
	D_1		D_2		D_3					
Units	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.
1		0.747		0.747		0.747		0		0.747
2										
3		0.623		0.622		0.622		.001		0.622
4										
5										
6										
7										
8										
9										
10										
11										

Where:

[a] $D_{1,2,3}$ = Three different nozzle diameters; Each diameter should be measured to the nearest 0.025mm (0.001 in.)

[b] ΔD = Maximum difference between any two diameters; $\Delta D \leq 0.10$ mm (0.004 in.)

[c] D_{avg} = Average of D_1, D_2, and D_3

Operator: Kyle Blasch Signature: Kyle Blasch

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot Tube Assembly Level? X yes _____ no

Pitot Tube Openings Damaged? _____ yes (explain below) X no

α_1 = 1 ° (<10°) α_2 = 2.5 ° (<10°)

β_1 = 3 ° (<5°) β_2 = 1 ° (<5°)

γ = 0.5 °

θ = 0.2 °

A = 0.88 cm (in.)

$z = A \sin\gamma$ = 0.0077 cm (in.); <0.32 cm (<1/8 in.)

$w = A \sin\theta$ = 0.0031 cm (in.); <0.08 cm (<1/32 in.)

P_a = 0.480 cm (in.)

P_b = 0.450 cm (in.)

D_t = 0.375 cm (in.)

Comments: _____

Calibration Required? ✓ yes _____ no

Operator: KYLE BLASCH Signature: [signature] 31 Jul 96

TYPE S PITOT TUBE INSPECTION DATA FORM

Pitot Tube Assembly Level? X yes _____ no
Pitot Tube Openings Damaged? _____ yes (explain below) X no

α_1 = 3° (<10°) α_2 = 5° (<10°)
β_1 = 2° (<5°) β_2 = 3° (<5°)

γ = 2.2°
θ = 1°
A = .916 cm (in.)

z = A sinγ = ~~0.035~~ 0.035 cm (in.); <0.32 cm (<1/8 in.)
w = A sinθ = 0.0174 cm (in.); <0.08 cm (<1/32 in.)

P_a = .461 cm (in.)
P_b = .455 ~~cm~~ (in.)
D_t = .375 ~~cm~~ (in.)

Comments: .461 + .455 = A = .916

.461
.455
.916

Calibration Required? ✓ yes _____ no

Operator: Kyle Nash Signature: Kyle Nash

APPENDIX D

```
DIA INCHES?
              36,0000
NIPPLE INCH ?
               5,2500
POINTS ONE TRV?
              12,0000
POINT  1,                6,3
POINT  2,                7,7
POINT  3,                9,5
POINT  4,               11,6
POINT  5,               14,3
POINT  6,               18,1
POINT  7,               28,4
POINT  8,               32,3
POINT  9,               34,9
POINT  10,              37,0
```

RUN

RUN

RUN

XROM "METH

```
DIA INCHES?
              17,0000
NIPPLE INCH ?
               0,0000
POINTS ONE TRV?
              10,0000
POINT  1,
POINT  2,
POINT  3,
POINT  4,
POINT  5,
POINT  6,
POINT  7,
POINT  8,
POINT  9,
```

```
STACK DIA INCH?
          36,0000     RUN
NO TRAV PTS. ?
          12,0000     RUN
BAR PRESS ?
          30,0200     RUN
STATIC IN H0H ?
           .0900      RUN
% MOISTURE ?
           8,0000     RUN
PITOT CP ?
           .8400      RUN
% CO2 ?
           8,0000     RUN
% OXYGEN ?
           8,0000     RUN
% CO ?
           0,0000     RUN
MOL WT OTHER ?
           0,0000     RUN
```

```
 TACK TEMP?
          620,        RUN
 PS = 8,

 ELTA P 2,
             .01      RUN
 TACK TEMP?
          650,        RU
 PS = 8,

 ELTA P 3,
             .01      RUN
STACK TEMP?
          730,        RU
 PS = 8,

 ELTA P 4,
             .01      RU
 TACK TEMP?
          850,        RU
 PS = 9,

 ELTA P 5,
             .01      RU
 TACK TEMP?
          950,        RU
 PS = 9,

DELTA P 6,
             .01      Run
STACK TEMP?
        1.083,        RU
 PS = 10,

 ELTA P 7,
             .01      RU
 TACK TEMP?
        1.125,        RU
 PS = 10,

 ELTA P 8,
             .01      R
 TACK TEMP?
        1.125,        R
 PS = 10,

 ELTA P 9,
             .01      R
 TACK TEMP?
        1.120,        R
 PS = 10,

 ELTA P 10,
             .01      R
 TACK TEMP?
        1.116,        R
 PS = 10,

DELTA P 11,
             .01      R
STACK TEMP?
        1.090,        R
FPS = 10,

DELTA P 12,
             .01      RUN
STACK TEMP?
        1.078,        RUN
FPS = 10,

AVE FPS = 9,
AVE FPM = 552,
AVE DELTA P = 0,01
```

```
TATIC H0H ?  ROM  NUZZLE"
             -.09     RUN
BAR PRESS ?
          30,02       RUN
STK TEMP ?
        961,00        RUN
  H0H ?
           8,00       RUN
STACK FPS ?
```

```
RUN
HICKAM AF3
TYPE 0 INCIN ONE
                                  RUN
METER BOX Y?
            1,0030                RUN
DELTA H?
            3,5900                RUN
BAR PRESS ?
           30,0100                RUN
METER VOL ?
           34,2660                RUN
MTR TEMP F?
           91,0000                RUN
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
            0,0000                RU
STATIC HOH IN ?
            -.0900                RU
STACK TEMP.
          781,0000                RUN
ML. WATER ?
           88,0000                RU

IMP. % HOH = 7,3
% HOH=7,3

% CO2?
             .0700                RU
% OXYGEN?
           21,0000                R
% CO ?
            0,0000                R
MOL WT OTHER?
            0,0000                RU

MWd =28,85
MW WET=28,06

SQRT PSTS ?
            5,2665                R
TIME MIN ?
           60,0000                R
NOZZLE DIA ?
             .7470                R
STK DIA INCH ?
           36,0000                R

* VOL MTR STD = 52,774
  STK PRES ABS = 30,00
  VOL HOH GAS = 4,14
  % MOISTURE = 7,28
  MOL DRY GAS = 0,927
  % NITROGEN = 78,93
  MOL WT DRY = 28,85
  MOL WT WET = 28,06
  VELOCITY FPS = 13,03
  STACK AREA = 7,07
  STACK ACFM = 5.528,
* STACK DSCFM = 2.187.
```

```
·UN NUMBER
·ICKAM AFB
TYPE 0 INCIN THREE
·ETER BOX Y?
            1,0030
·ELTA H?
             .9900
·AR PRESS ?
           30,0700
·ETER VOL ?
           32,0650
·TR TEMP F?
           92,0000
% OTHER GAS
·EMOVED BEFORE
DRY GAS METER ?
            0,0000
STATIC HOH IN ?
            -.0900
STACK TEMP.
        1.201,0000
ML. WATER ?
           81,5000

IMP. % HOH = 11,0
% HOH=11,0

% CO2?
            8,2700
% OXYGEN?
           10,7300
% CO ?
            0,0000
MOL WT OTHER?
            0,0000

MWd =29,75
MW WET=28,46

SQRT PSTS ?
            4,0590                R
TIME MIN ?
           60,0000                R
NOZZLE DIA ?
             .7470                R
STK DIA INCH ?
           36,0000                R

* VOL MTR STD = 30,99
  STK PRES ABS = 30,0
  VOL HOH GAS = 3,84
  % MOISTURE = 11,01
  MOL DRY GAS = 0,890
  % NITROGEN = 81,00
  MOL WT DRY = 29,75
  MOL WT WET = 28,46
  VELOCITY FPS = 9,97
  STACK AREA = 7,07
  STACK ACFM = 4.226,
* STACK DSCFM = 1.201,
                      99,9
```

```
HICKAM AFB
TYPE 0 INCIN FOUR
METER BOX Y?
            1,0030
DELTA H?
            1,2300
BAR PRESS ?
           30,0200
METER VOL ?
           35,4340
MTR TEMP F?
           93,0000
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
            0,0000
STATIC HOH IN ?
            -.0900
STACK TEMP.
          961,0000
ML. WATER ?
          102,5000

IMP. % HOH = 12,4
% HOH=12,4

% CO2?
            7,2000
% OXYGEN?
           11,0000
% CO ?
            0,0000
MOL WT OTHER?
            0,0000

MWd =29,59
MW WET=28,16

SQRT PSTS ?
            3,8200                R
TIME MIN ?
           60,0000                R
NOZZLE DIA ?
             .7470                R
STK DIA INCH ?
           36,0000                R

* VOL MTR STD = 34,145
  STK PRES ABS = 30,01
  VOL HOH GAS = 4,82
  % MOISTURE = 12,38
  MOL DRY GAS = 0,876
  % NITROGEN = 81,80
  MOL WT DRY = 29,59
  MOL WT WET = 28,16
  VELOCITY FPS = 9,44
  STACK AREA = 7,07
  STACK ACFM = 4.002,
  STACK DSCFM = 1.307,
  % ISOKINETIC =  101,.
```

APPENDIX E

Table E.1 Hickam AFB Incinerator Survey Filter Weights

Run #	1st Weight 29Aug/0900 (g)	2nd Weight 29Aug/1500 (g)	3rd Weight 30Aug/0745 (g)	4th Weight 30Aug/1500 (g)	5th Weight 3Sep/0730 (g)
T1I - 01	0.4072	0.4057	0.4069	0.4051	0.4048
T1I - 03	0.3122	0.3114	0.3121	0.3114	0.3112
T1I - 04	0.3272	0.3265	0.3269	0.3262	0.3258

Table E.2 Particulate Matter From Filter Collection

Run #	Filter Initial Weight (g)	Filter Final Weight (g)	Particulate Matter Weight (g)	Total PM For Each Run (g)
T1I - 01	0.2864	0.4050	0.119	0.119
T1I - 03	0.2895	0.3113	0.0218	0.0218
T1I - 04	0.2889	0.3260	0.0371	0.0371

Table E.3 Particulate Matter From Acetone Rinse

Run #	Initial Weight 29Aug/1600 (g)	1st Weight 5Sep/0745 (g)	2nd Weight 5Sep/1600 (g)	Final Weight (g)	Acetone Rinse Weight (g)
Blank	162.9687	162.9682	162.9680	162.9681	-0.0006
T1I - 01	165.8259	165.9099	165.9095	165.9097	0.0838
T1I - 03	162.7079	162.7862	162.7862	162.7862	0.0783
T1I - 04	166.1486	166.2308	166.2304	166.2306	0.0820

Table E.4 Type "1" Incinerator Stack Sampling Results

	Run 1	Run 3	Run 4	Average
Test Date	6 Aug 96	9 Aug 96	12 Aug 96	
Test Start Time (Military)	1045-1145	1000-1100	1400-1500	
Station Pressure ("Hg)	30.01	30.07	30.02	
Stack Static Pressure ("H_2O)	-0.09	-0.09	-0.09	
Average Stack Gas Temperature (° F)	781	1201	961	
Stack Gas Moisture Content (%H_2O)	7.3	11.0	12.4	
Stack Gas Oxygen Content (%O_2)	21	10.73	11.0	
Stack Gas Carbon Dioxide Content (%CO_2)	.070	8.27	7.2	
Stack Gas Velocity (ft/sec)	13.03	9.97	9.44	
Actual Stack Gas Flow Rate (ACFM)	5528	4226	4002	
Corrected Flow Rate (DSCFM)	2187	1201	1307	
Total Gas Volume (DSCF)	54.266	32.065	35.434	
Percent Isokinetic	93.47	99.93	102.20	
Waste Incinerated (ton)	0.284	0.147	0.132	
PM Collected (lb)	4.46E-04	2.28E-04	2.62E-04	
PM Emission Rate (lb/ton)	3.80	3.48	4.39	**3.89**

Units
"Hg = inches of mercury
"H_2O = inches of water
° F = degrees Fahrenheit
%H_2O = percent moisture
%O_2 = percent oxygen
ft/sec = feet per second
ACFM = actual cubic feet per minute
DSCFM = dry standard cubic feet per minute
lb/hr = pounds per hour Note: lb/hr = (ppm) (MW) (DSCFM) (1.55×10^{-7})

State of Hawaii Permit Limits
Particulate Matter: 4.0 lb/ton

Preliminary Survey Data Sheet							
Dwell Time Calculation							
Base:	Hickam AFB			Date:	2 Aug		
Source:	Type "I" Incinerator			Time:	10:00		
Inside Stack Diameter (Inches):		36 in					
Stack Static Pressure (In H_2O):		-0.09					
Station Pressure (In. Hg):		30.02					
Sampling Data:							

Traverse Point Number	Stack Temperature (°F)	Velocity Head (Δp In. H_2O)	$(\Delta p)^{0.5}$	Dwell Time (min)	Cyclonic Flow (°)	Abs Flow (°)
1	620	0.01			0	
2	650	0.01			0	
3	730	0.01			0	
4	850	0.01			5	
5	940	0.01			0	
6	1063	0.01			0	
7	1125	0.01			0	
8	1125	0.01			0	
9	1120	0.01			0	
10	1116	0.01			0	
11	1090	0.01			0	
12	1078	0.01			0	
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
Average =	961	0.01			0.42	

Operator: GREG Durand Signature: [signature]

Impinger and Orsat Analysis Data Sheet

Base: HICKAM AFB Date: 6 Aug 96

Source: TYPE "O" RUN 1 Time: 13:55

I. IMPINGER ANALYSIS

ITEM	FINAL VOLUME (ml)	INITIAL VOLUME (ml)	VOLUME WATER (ml)
IMPINGER 1 (H_2O)	153	100	53
IMPINGER 2 (H_2O) Standard Tip	115	100	15
IMPINGER 3 (H_2O)	0	0	0
IMPINGER 4 (Silica Gel)	220	200 gm	20
	Total Volume of Water Collected		88

II. MIGHTY ORSAT

Scratch Space:

0.0 0.0 .2 .2 0.0 0.0
15.6 19.4 30.6 21.0 21.2 21.2 19.6 19.9 21.0 21.0
21.0

6.72 0.088 + 6.72 + 22.064

CO_2 = Reading A; O_2 = Reading B-A; CO_2 = Reading C-B; N_2 =(100% - $\%CO_2$ - $\%O_2$ - $\%CO_2$);

DMW = 0.440(%CO2) + 0.320(%O2) + 0.280(%CO + %N2)

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	AVERAGE	COMMENT
Reading A	0.0	0.2	0.0		
Reading B	21.0	21.2	21.0		
Reading C	–	–	–		
VOL% CO_2	0.0	0.2	0.0		
VOL% O_2	21.0	21.0	21.0	21.0	
VOL% CO	–	–	–		
VOL% N_2	79.0	78.8	79.0		
Dry Molecular Weight	28.84	28.872	28.84	28.851	

Fuel Factor: F_o = (20.9 - $\%O_2$) / $\%CO_2$ = _____ F_o (Natural Gas): 1.600 - 1.836

Operator: Kyle Blanch Signature: Kyle Blanch

168.536
114.270
54.266

568 163

Particulate Sampling Data Sheet

Date: 6 Aug 96	Nozzle Diameter: 0.747 in	Pre Pitot Check: yes	Schematic of Stack		
Base: HICKAM	Pitot Coefficient, C_p: 0.84	Post Pitot Check: yes			
Source ID: TYPE "O" INCIN	Meter Box Y_i: 1.003	Pre Train Check: yes (at 15 "Hg)			
Run Number: 1	Meter Box ΔH@: 1.763	Post Train Check: yes (at 22 "Hg)			
Station Pressure: 30.01 "Hg	Meter Box #: 4	Assumptions			
Static Pressure: -.09 "H_2O	Probe #: 6Ft	%H_2O: 7.5	MW_D: 29.24		

Traverse Point Number	Sampling Time (min)	Dry Gas Meter Vol (ft^3)	Gas Meter Temp, T_m In (°F) 6	Gas Meter Temp, T_m Out (°F) 7	Stack Temp, T_s (°F) 1	Velocity Head, Δp ("H_2O)	Orifice Diff Press, ΔH ("H_2O)	Probe Temp (°F) 2	Sample Box Temp (°F) 3	Impinger Outlet Temp (°F) 4	Vacuum Pressure ("Hg)
	66	~~114.067~~									
		114270									
1	2.5 min	"	90	88	230	.02	4.58	250	238	54	6
2		✓	87	87	281	.02	4.25	249	235	50	6
3		✓	87	87	327	.025	7.03	250	240	52	11
4		✓	88	86	334	.025	4.96	249	241	54	9
5		✓	88	86	345	.040	8.87	250	240	55	15
6		✓	89	86	361	.035	6.71	251	238	56	15
7		✓	89	86	360	.035	6.72	251	232	57	16
8		✓	90	86	374	.035	6.62	253	225	60	17
9		✓	90	87	383	.030	3.74	254	227	61	13
10		✓	91	87	391	.025	4.64	254	253	61	14
11		✓	93	88	1009	.015	1.62	266	246	63	11
12		✓	94	89	1011	.015	1.62	269	263	63	10
13		✓	95	89	1061	.025	2.61	267	248	62	14
14		✓	96	90	1104	.020	2.03	268	250	62	14
15		✓	97	90	1135	.025	2.50	267	250	63	16
16		✓	98	91	1159	.025	2.46	270	245	64	17
17		✓	98	91	1171	.020	1.96	270	253	64	17
18		✓	98	91	1178	.020	1.85	269	252	64	17
19		✓	98	92	1165	.020	1.97	263	250	64	18
20		✓	98	92	1154	.020	1.88	254	236	65	18
21		✓	98	92	1116	.020	2.03	243	247	65	18
22		✓	98	92	1115	.020	2.03	234	250	64	18
23		✓	98	93	1083	.020	2.07	230	248	65	20
24		168.536	98	93	894	.020	2.36	229	246	66	22
Total Gas Vol =		54.266	Avg T_m =	91	Avg T_s =	781	Avg ΔH =	3.59	Avg $(P_sT_s)^{0.5}$ =		52665

Nov 95

Meter Box Operator: GREG Durand

Signature:

Impinger and Orsat Analysis Data Sheet

Base: HICKAM AFB Date: 8 Aug

Source: TYPE "O" Incin Run #2 Time: 13:30

I. IMPINGER ANALYSIS

ITEM	FINAL VOLUME (ml)	INITIAL VOLUME (ml)	VOLUME WATER (ml)
IMPINGER 1 (H_2O)	183	100	83
IMPINGER 2 (H_2O) Standard Tip	60	100	-40
IMPINGER 3 (H_2O)	0	0	0
IMPINGER 4 (Silica Gel)	206	200 gm	6
	Total Volume of Water Collected		49

no visible movement dim recd checks

II. MIGHTY ORSAT

Scratch Space:

6.4 6.4 6.9 7.0 7.0 7.0 7.0

17.2 17.2 15.8 18.6 16.4 18.9

18.3 18.3 18.9 18.9 19.0 19.0

2.816 + 3.808 + 22.876 3.0802 3.808 + 22.708 3.0807 + 3.84 + 22.6800

CO_2 = Reading A; O_2 = Reading B-A; CO_2 = Reading C-B; N_2 =(100% - $\%CO_2$ - $\%O_2$ - $\%CO_2$);

DMW = 0.440(%CO2) + 0.320(%O2) + 0.280(%CO + %N2)

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	AVERAGE	COMMENT
Reading A	6.4	7.0	7.0	6.8	
Reading B	18.3	18.9	19.0		
Reading C					
VOL% CO_2	6.4	7.0	7.0	6.8	
VOL% O_2	11.9	11.9	12.0	11.9333	
VOL% CO	-	-	-		
VOL% N_2	81.7	81.1	81.0		
Dry Molecular Weight	29.500	29.5967	29.6067	29.5658	

Fuel Factor: F_o = (20.9 - $\%O_2$) / $\%CO_2$ = _____ F_o (Natural Gas): 1.600 - 1.836

Operator: Kyle Blasch Signature: Kyle Blasch

lbs Burned 149

Particulate Sampling Data Sheet

Date: 6 Aug 96	Nozzle Diameter: 0.747 in	Pre Pitot Check: yes	Schematic of Stack		
Base: HILL AFB	Pitot Coefficient, C_p: 0.84	Post Pitot Check: yes			
Source ID: TYPE "D" INCIN	Meter Box Y_i: 1.003	Pre Train Check: yes (at 15 "Hg)			
Run Number: TW3	Meter Box $\Delta H@$: 1.763	Post Train Check: yes (at 6 "Hg)			
Station Pressure: 30.01 "Hg	Meter Box #: 4	Assumptions			
Static Pressure: -0.09 "H_2O	Probe #: 4	%H_2O: 7.5 MW_D: 30.0			

Traverse Point Number	Sampling Time (min)	Dry Gas Meter Vol (ft^3)	Gas Meter Temp, T_m 6 In (°F)	Gas Meter Temp, T_m 7 Out (°F)	Stack Temp, T_s 1 (°F)	Velocity Head, Δp ("H_2O)	Orifice Diff Press, ΔH ("H_2O)	Probe 2 Temp (°F)	Sample Box Temp 3 (°F)	Impinger Outlet Temp 4 (°F)	Vacuum Pressure ("Hg)
		217.572									
1 A	2.5 min		89	90	124	.015	2.57	248	244	67	5
2	"		90	90	280	.020	2.70	250	248	64	6
3	"		91	90	345	.015	1.87	252	250	60	5
4	"		92	90	388	.015	1.77	252	248	62	5
5	"		92	90	400	.020	2.33	253	246	62	6
6	"		93	90	399	.020	2.33	253	238	62	7
7	"		94	90	1008	.015	1.03	257	232	65	5
8	"		94	90	999	.010	0.69	260	236	65	4
9	"		94	90	1026	.015	1.01	260	238	64	5
10	"		94	91	1048	.015	1.00	260	242	61	5
11	"		95	91	1066	.015	1.86	262	244	61	8
12	"		96	91	1077	.010	0.65	267	246	59	5
		236.350									
1 B	2.5 min	236.450	91	91	985	.010	0.69	244	228	51	4
2	"		92	91	1120	.015	0.95	245	232	50	5
3	"		92	91	1233	.015	0.89	250	236	52	6
4	"		94	92	1250	.015	0.88	250	242	53	6
5	"		94	92	1278	.015	0.87	250	242	54	6
6	"		95	92	1295	0.015	0.86	249	244	55	6
7	"		96	93	1306	.015	0.86	248	248	56	6
8	"		97	93	1310	.010	0.57	244	248	57	4
9	"		97	93	1303	.010	0.57	247	248	59	4
10	"		98	94	1298	.010	0.58	249	245	58	5
11	"		98	94	1296	.010	0.58	251	246	58	5
12	"		98	94	1294	.010	0.58	250	246	58	5
		253.809									
Total Gas Vol =		34.037	Avg T_m =	113	Avg T_s =	964	Avg ΔH =	1.19	Avg $(P_s T_s)^{0.5}$ =	4.337	

Nov 95

② 251.809 − 236.450 = 15.259 ; 236.550 − 217.572 = 18.978 ; 15.259 + 18.778 = 34.037

Meter Box Operator: Greg Durand

Signature:

Impinger and Orsat Analysis Data Sheet

Base: Hickam AFB Date: 9 Aug 96
Source: TO 3 Time: 1400

I. IMPINGER ANALYSIS

ITEM	FINAL VOLUME (ml)	INITIAL VOLUME (ml)	VOLUME WATER (ml)
IMPINGER 1 (H_2O)	202	100	102
IMPINGER 2 (H_2O) Standard Tip	~~172~~ 72	100	-28
IMPINGER 3 (H_2O)	0	0	0
IMPINGER 4 (Silica Gel)	207.5	200 gm	7.5
	Total Volume of Water Collected		81.5

II. MIGHTY ORSAT

Scratch Space:

8.2 8.2
19.0 19.0

9.0 9.0
18.6 18.6

6.8 7.6 7.6
19.4

3.6 + 3.456 + 22.68 3.96 + 3.072 + 22.792 3.344 + 3.776 + 22.568

CO_2 = Reading A; O_2 = Reading B-A; CO_2 = Reading C-B; N_2 =(100% - $\%CO_2$ - $\%O_2$ - $\%CO_2$);

DMW = 0.440(%CO2) + 0.320(%O2) + 0.280(%CO + %N2)

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	AVERAGE	COMMENT
Reading A	8.2	9.0	7.6	8.2667	
Reading B	19.0	18.6	19.4	19.00	
Reading C					
VOL% CO_2	~~18.2~~ 8.2	9.0	7.6	8.27	
VOL% O_2	10.8	9.6	11.8	10.73	
VOL% CO	-	-	-		
VOL% N_2	81.0	81.4	80.6	81	
Dry Molecular Weight	29.736	29.824	29.688	29.7493	

Fuel Factor: F_o = (20.9 - $\%O_2$) / $\%CO_2$ = [ ] F_o (Natural Gas): 1.600 - 1.836

Operator: Kyle Blazek Signature: [signature]

293 lbs

Particulate Sampling Data Sheet

Date: 9AUG 96	Nozzle Diameter: 0.747 in	Pre Pitot Check: yes	Schematic of Stack		
Base: HICKAM AFB	Pitot Coefficient, C_p: 0.84	Post Pitot Check: yes			
Source ID: TYPE "0" INCIN	Meter Box Y_i: 1.003	Pre Train Check: yes (at 15 "Hg)			
Run Number: THREE	Meter Box ΔH@: 1.763	Post Train Check: yes (at 3.5 "Hg)			
Station Pressure: 30.07 "Hg	Meter Box #: 4	Assumptions			
Static Pressure: +0.09 "H_2O	Probe #: 6ft	%H_2O: 7.5 MW_D: 30.0			

Traverse Point Number	Sampling Time (min)	Dry Gas Meter Vol (ft^3)	Gas Meter Temp, T_m In (°F)	Gas Meter Temp, T_m Out (°F)	Stack Temp, T_s (°F)	Velocity Head, Δp ("H_2O)	Orifice Diff Press, ΔH ("H_2O)	Probe Temp (°F)	Sample Box Temp (°F)	Impinger Outlet Temp (°F)	Vacuum Pressure ("Hg)
		252.214									
1A	2.5"		87	87	470	.01	1.79	252	250	61	1.5
2	"		88	87	560	.01	1.55	253	249	58	2.0
3	"		88	87	799	.01	1.25	254	253	57	2.0
4	"		89	87	985	.01	1.09	256	250	59	2.0
5	"		90	88	1168	.01	0.97	258	251	59	2.0
6	"		91	88	1224	.01	0.94	259	247	57	2.0
7	"		92	89	1295	.01	0.90	262	257	57	2.5
8	"		93	89	1305	.01	0.90	260	252	57	2.5
9	"		93	89	1312	.01	0.90	258	253	57	3.0
10	"		93	89	1314	.01	0.89	252	253	57	3.0
11	"		94	89	1319	.01	0.89	253	249	58	3.0
12	"		94	89	1319	.01	0.89	254	248	58	3.0
		268.545									
1B	2.5"	268.797	~~94~~ 92	~~89~~ 91	~~1319~~ 880	~~.01~~ .01	0.89 1.89	~~254~~ 238	~~248~~ 251	~~58~~ 58	~~3.0~~ 3.5
2	"		93	91	1115	.01	1.01	240	252	53	3.5
3	"		94	92	1295	.01	0.91	242	252	54	3.5
4	"		95	92	1354	.01	0.88	242	246	54	3.0
5	"		95	92	1372	.01	0.87	242	252	55	3.0
6	"		95	92	1371	.01	0.86	241	251	57	3.0
7	"		96	93	1394	.01	0.86	243	248	59	3.0
8	"		97	93	1389	.01	0.86	244	249	58	3.0
9	"		97	93	1401	.01	0.86	247	248	60	3.0
10	"		98	94	1405	.01	0.86	249	251	60	3.0
11	"		98	94	1401	.01	0.86	248	251	60	3.0
12	"		99	94	1398	.01	0.86	251	253	60	3.0
		284.531									
Total Gas Vol =		32.065	Avg T_m =	92	Avg T_s =	1201	Avg ΔH =	0.99	Avg $(P_sT_s)^{0.5}$ =		4.059

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268.545 − 252.214 = 16.331

284.531 − 268.797 = 15.734

15.734 + 16.331 = 32.065

Meter Box Operator: Greg Durand

Signature:

Impinger and Orsat Analysis Data Sheet

Base: HICKAM AFB Date: 12 Aug 96

Source: TO-4 Time: 16:00

I. IMPINGER ANALYSIS

ITEM	FINAL VOLUME (ml)	INITIAL VOLUME (ml)	VOLUME WATER (ml)
IMPINGER 1 (H_2O)	215	100	115
IMPINGER 2 (H_2O) Standard Tip	81	100	-19
IMPINGER 3 (H_2O)	0	0	0
IMPINGER 4 (Silica Gel)	206.5	200 gm	6.5
	Total Volume of Water Collected		102.5

II. MIGHTY ORSAT

Scratch Space:

7.3 7.3 7.0 ~~7.8~~ 7.2 7.3 7.3

17.4 18.8 17.8 17.9 17.5 17.8 17.6

18.9 18.9

3.212 + 3.312 + 22.708 3.108 + 3.480 + 22.986 3.212 + 3.36 + 23.016

CO_2 = Reading A; O_2 = Reading B-A; CO_2 = Reading C-B; N_2 =(100% - %CO_2 - %O_2 - %CO_2);

DMW = 0.440(%CO2) + 0.320(%O2) + 0.280(%CO + %N2)

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	AVERAGE	COMMENT
Reading A	7.3	7.0	7.3		
Reading B	18.9	17.9	17.8		
Reading C					
VOL% CO_2	7.3	7.0	7.3	7.2	
VOL% O_2	11.6	10.9	10.5	11	
VOL% CO	–	–	–		
VOL% N_2	81.1	82.1	82.2		
Dry Molecular Weight	29.632	29.584	29.588	29.603	

Fuel Factor: F_o = (20.9 - %O_2) / %CO_2 = [ ] F_o (Natural Gas): 1.600 - 1.836

Operator: Kyle Nasch Signature: Kyle Nasch

16.154
18.681
34.835

264 lbs

Particulate Sampling Data Sheet

Date: 12 Aug	Nozzle Diameter: 0.747 in	Pre Pitot Check: Yes	Schematic of Stack		
Base: HICKAM	Pitot Coefficient, C_p: 0.84	Post Pitot Check: Yes			
Source ID: TYPE "O"	Meter Box Y_i: 1.003	Pre Train Check: Yes (at 15 "Hg)			
Run Number: 4	Meter Box ΔH@: 1.763	Post Train Check: / (at __ "Hg)			
Station Pressure: 30.00 "Hg	Meter Box #: 4	Assumptions			
Static Pressure: .095 "H_2O	Probe #: 6ft	%H_2O: 7.5 MW_D: 30.0			

Traverse Point Number	Sampling Time (min)	Dry Gas Meter Vol (ft^3)	Gas Meter Temp, T_m In (°F)	Gas Meter Temp, T_m Out (°F)	Stack Temp, T_s (°F)	Velocity Head, Δp ("H_2O)	Orifice Diff Press, ΔH ("H_2O)	Probe Temp (°F)	Sample Box Temp (°F)	Impinger Outlet Temp (°F)	Vacuum Pressure ("Hg)
		345.702									
1	2.5 min		93	92	250	.01	2.24	253	254	64	3
2	"		92	92	480	.01	1.69	257	257	59	3
3	"		93	92	680	.01	1.40	258	254	59	3
4	"		94	92	805	.015	1.89	253	252	60	3.5
5	"		95	92	830	.015	1.85	256	251	60	4.0
6	"		96	92	870	.01	1.20	255	244	58	3.0
7	"		96	93	930	.01	1.15	255	247	58	3.5
8	"		96	93	980	.01	1.11	259	255	59	3.5
9	"		96	93	1020	.01	1.08	258	250	58	3.5
10	"		96	93	1060	.01	1.05	260	251	59	4.0
11	"		97	93	1130	.01	1.01	256	246	59	4.0
12	"	364.383	97	93	1144	.01	1.00	259	250	59	4.0
		364.543									
1	2.5 min		91	90	440	.01	1.76	248	251	58	5.0
2	"		92	91	820	.01	1.24	249	250	50	4.5
3	"		93	91	970	.01	1.11	250	248	51	4.5
4	"		93	91	985	.01	1.10	250	252	52	5.0
5	"		94	91	1016	.01	1.08	254	245	52	5.0
6	"		94	91	1057	.01	1.05	253	252	54	5.0
7	"		95	91	1072	.01	1.04	256	253	55	5.0
8	"		95	91	1198	.01	0.96	255	251	56	5.0
9	"		95	92	1295	.01	0.91	253	251	57	5.0
10	"		96	92	1326	.01	0.89	254	252	58	5.0
11	"		96	92	1340	.01	0.89	257	251	59	5.0
12	"	381.217	96	92	1355	.01	0.88	255	252	59	5.0
Total Gas Vol =		36.434	Avg T_m =	93	Avg T_s =	961	Avg ΔH =	1.23	Avg $(P_s T_s)^{0.5}$ =		3.8155

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364.383 − 345.702 = 18.681
381.217 − 364.543 = 16.754

Meter Box Operator: Greg Durand

Signature: